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# INTRODUCTION

The Global Positioning System (GPS), in its current form, is used within the transportation industry for vehicle tracking and navigation. With the advent of a nationwide differential GPS (DGPS) service, this role will expand to include public safety, infrastructure management, mayday services, and other yet unknown applications. The U.S. department of Transportation is considering a nationwide DGPS service, modeled after the U.S. Coast Guard's Local Area Differential GPS system, to support surface applications. This service, when fully implemented, will provide accurate navigation and positioning information across the nation, promoting safety and efficiency in transportation and other fields.

## 1.1 Background

The NAVSTAR Global Positioning System (GPS) is a space based radionavigation system which is operated for the Federal Government by the Department of Defense (DOD) and jointly managed by the DOD and Department of Transportation (DOT). GPS consists of a constellation of 24 satellites in 6 orbital planes; it provides accurate three-dimensional position, velocity, and precise time to users worldwide, 24 hours per day. GPS was originally developed as a military force enhancement system. Although still used in this capacity, GPS also provides significant benefits to the civilian community. In an effort to make GPS service available to the greatest number of users while ensuring that the national security interests are protected, two GPS services are provided. Positional accuracy available to certain authorized (i.e. military) users of GPS, designated as Precise Positioning Service (PPS), is 21 meters “two distance root mean square” (2drms). Due to encryption of the PPS signals, all other users have access to only the less accurate Standard Positioning Service (SPS). SPS accuracy without Selective Availability (SA) is 54 meters (2drms). With the addition of SA and Anti-Spoofing (AS) techniques, non-authorized user accuracy has been intentionally degraded to approximately 100 meters. Differential GPS (DGPS) augments SPS to provide higher accuracy positioning and increased integrity of the positioning information.

Recent studies of GPS and DGPS have documented the navigation and positioning needs of the GPS user community.<sup>[1,2,3]</sup> The information presented in these studies indicates that SPS accuracy of 100 meters does not meet most civil navigation and positioning requirements. Many users cited accuracy requirements of 10 meters or better for real time navigation and positioning applications, while surveying and mapping accuracy requirements were determined to be 1 meter or better. Most users would like to have the highest possible accuracy, if cost of the system was no object. Practical considerations of available technology and cost effective system implementation allow design of a nationwide DGPS service that will meet the requirements of a majority of the users. Although position accuracy is an important consideration to DGPS users, other factors are equally important to many users. Availability, defined as the percentage of time that the position signal is available to the user, and integrity, defined as the time required to alert the user to problems with the DGPS

information, are also important factors in many applications. These elements can be improved with a nationwide DGPS service.

## **1.2 Purpose**

The purpose of this document is to familiarize individuals responsible for the implementation of a DGPS system with the concept, configuration, operation, and performance of a nationwide DGPS service. The general requirements for DGPS broadcast site selection, and the recommended locations of broadcast sites, to complete nationwide coverage of the DGPS correction signal, are presented. The equipment required for broadcast site operation is described, along with the basic operation of this equipment. This document does not provide detailed engineering drawings or specifications for the DGPS broadcast site or the required equipment. Refer to the U.S. Coast Guard "Differential GPS Broadcast Equipment Technical Manual," GCF-W-1216-DGPS, and related documents for detailed information.

## **1.3 Benefits of a Nationwide DGPS Service**

The benefits that will be derived from a nationwide DGPS service are numerous, affecting commerce, transportation, law enforcement, the environment, recreation, and many other aspects of daily life. Although the major emphasis of the service will be the nationwide improvement of public safety, there are many other areas that will realize benefits from this service. As one example, GPS provides a precise timing signal that even without augmentation is accurate enough to satisfy many of the timing requirements of the telecommunications industry and the power industry. But since these industries are required to satisfy their customers needs on a continuous 24 hour-a-day basis, they are hesitant to utilize GPS due to concerns about system reliability.<sup>[2]</sup> The ability of the DGPS service to provide integrity monitoring with rapid notification of problems, will relieve these concerns and make this valuable precise timing information available to these industries. In an entirely different area of operations, these industries will benefit from the accurate position information provided by DGPS, allowing accurate cataloging and maintenance of the nationwide infrastructure of power transmission lines and communications lines.

All modes of transportation including ships, boats, trucks, buses, automobiles, and even skiers and hikers, have requirements for position information, navigation, and safety that can be satisfied by a nationwide DGPS service. The requirements for transportation on the waterways are being met by the DGPS services being provided by the U.S. Coast Guard (USCG) and U.S. Army Corps of Engineers (COE). Expanding this system to a nationwide DGPS service will provide the same level of service for land transportation, where the potential users far out number the waterway users. The benefits that will be realized by land transportation users are as diverse as the industries that will use the service. Public transportation can increase the safety and efficiency of operations with real-time information on the location of buses. The trucking industry will be able to track their carriers across the nation, improving scheduling, reducing cost, and improving road safety. Hazardous material shipments will be tracked in real-time, avoiding environmental concerns. Small package shippers will control the movement of their deliveries and easily locate the destination of packages. All just-in-time manufacturers will benefit as they schedule on-time delivery of materials and distribution of product.

The Intelligent Transportation System (ITS) will be one of the larger markets for DGPS services, as navigation and location devices are incorporated into automobiles and light trucks. Several rental car agencies and some automobile manufacturers offer a GPS navigation system combined with a digital map as optional equipment. These systems also allow a driver to call for help in emergency situations. DGPS will make these navigation systems more accurate and useful. Navigation and route guidance for automobiles will be an important application of DGPS, but of even greater importance will be safety and security features. A DGPS receiver coupled with two way communications can provide the precise location of a vehicle in the event of an accident or emergency.

The railroads are evaluating the use of DGPS as a train location system on main lines, both inside and outside rail terminal areas, as a component of a Positive Train Control (PTC) system. PTC is targeted to improve railroad safety, increase rail system capacity, thereby improving productivity, and facilitate the growth of high speed passenger service and commuter service in the United States.<sup>[4]</sup>

One industry that will realize immediate benefits from the availability of nationwide DGPS service will be agriculture. The accurate positioning capability of DGPS will allow the seeding rate and application of pesticides and fertilizers to be adjusted. Environmental safety regulations require that certain pesticides not be applied near bodies of water, streams, or wells. DGPS will be particularly beneficial in aerial spraying of chemicals, providing the ability to apply the proper amount of chemical where it is needed and avoid areas that should not be sprayed, without exposing a flagman to the hazards of the chemical.

Another application where a nationwide DGPS service would have an immediate impact is surveying and mapping. The fact that DGPS can obtain an accurate location of a point, without a line of sight between adjacent surveyed points, as required by traditional survey techniques, provides an enormous cost reduction in the acquisition of accurate survey data. The nationwide DGPS service alone does not provide the real-time accuracy required for many surveying and mapping applications. However, the National Oceanic and Atmospheric Administration's program of Continuously Operating Reference Stations (CORS) is being installed at USCG and COE DGPS broadcast sites. CORS stores all data collected by the reference station and users can access this data electronically for post-processing that will provide position accuracies of 5 to 10 centimeters.<sup>[1]</sup> The National Park Service, the U.S. Fish and Wildlife Service, and other federal natural resource agencies plan to use DGPS for mapping and various natural resource inventory activities. Use of DGPS is more reliable and much less expensive than traditional surveying methods.<sup>[5]</sup>

Benefits of a nationwide DGPS service would be realized by a variety of recreational users including, pleasure boating, mountain climbing, skiing, hiking, and off road vehicles, as a few examples. These activities, particularly in remote areas, would benefit from the availability of accurate position information for guidance and navigation. Even more important is the life saving capability of avoiding getting lost, or if necessary, aiding search and rescue operations.

Police, Fire, and Ambulance services will benefit from the ability to navigate directly to the location of an emergency, reducing the time required to respond to potential life threatening situations. Emergency response to natural disasters such as floods, fires, and hurricanes will be improved with

accurate position information. Relief activities and clean-up after natural disasters will also be more efficient with a nationwide DGPS service.